INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory
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More Efficient X-Ray Cavity for Indirect-Drive ICF Demonstrated

We have recently demonstrated 5–10% improvement in the soft x-ray confinement efficiency of x-ray cavities (“hohlraums”) used for ICF. This was accomplished by switching from the traditional pure gold hohlraum wall material to a carefully fabricated and optimized mixture of high-Z elements (“cocktail”). Extrapolating to the NIF ignition hohlraum conditions indicate up to 12% increase in the x-ray energy available for driving the ignition capsule for a fixed laser energy.

The National Ignition Facility (NIF) is a 192-beam laser facility being constructed at Lawrence Livermore National Laboratory to ignite and burn deuterium-tritium (DT) plasmas in the laboratory. NIF uses the indirect-drive method for compressing and heating the DT fuel contained in small capsules. In this method, the capsule is placed in an enclosure made of high Z material such as gold, and the laser is focused inside the enclosure producing x rays to compress and heat the fuel. The enclosure, called a hohlraum, plays an important role because it converts the laser light to x rays and confines the x rays, preventing them from escaping. Its efficiency in performing this role is directly related to the size of laser needed to obtain ignition.

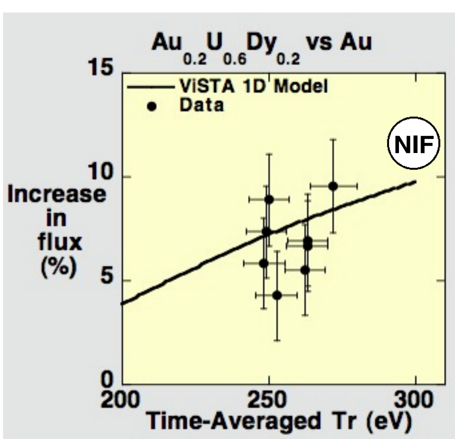

Figure 1. Increase in hohlraum soft x-ray radiation flux between cocktail hohlraum and gold hohlraum vs. time-averaged radiation temperature. The line is a prediction from a 1D model incorporating the latest equation of state and opacity models for the high-Z elements used.

In recent experiments performed at the Omega laser at the University of Rochester, we have demonstrated an average improvement in hohlraum soft x-ray confinement efficiency of 7% as expected (see Figure 1) for an average radiation temperature of 260 eV. This was achieved by switching from pure gold hohlraums to a hohlraum made of a mixture of gold, uranium, and dysprosium. The mixture helps fill in gaps in the absorptivity at particular x-ray wavelengths (see Figure 2), thereby reducing the energy lost in heating the wall material and improving the efficiency of reemission (see Figure 3). Also shown on Figure 1 is the expected improvement during the 300-eV peak of the NIF ignition pulse, where the majority of the laser energy is used, indicating the expected 12% increase in x-ray flux.

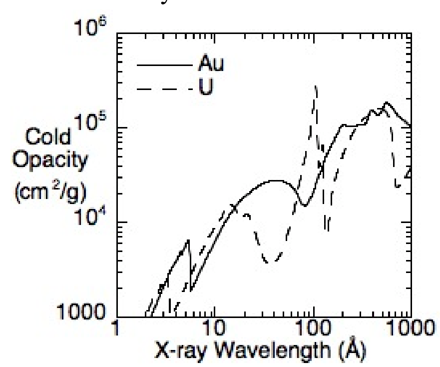

Figure 2. Example of how absorptivity or opacity (in this case for cold materials) vs. wavelength for two elements can fill in each other’s low points.

Key to the success of the recent experiments was mitigating formation of lossy oxide layers in the uranium through improved fabrication, handling, and storage procedures. These hohlraums were fabricated by co-sputtering materials on the inside two halves of a hohlraum mandrel that were rejoined during final assembly (see Figure 4). An improved method of fabrication is under development by our partners at General Atomics that is more suitable for routine production of ignition hohlraum assemblies. This method is based on thin, alternating deposition of layers of the high-Z materials. Hohlraums fabricated by this method have also demonstrated the expected efficiency improvements.

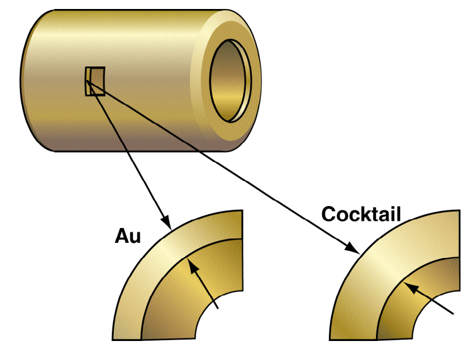

Figure 3. Schematic of hohlraum with cut-away inner wall showing reduction in heated wall depth for cocktail (right) vs. gold (left), which leads to more x-ray energy being available to drive a capsule.

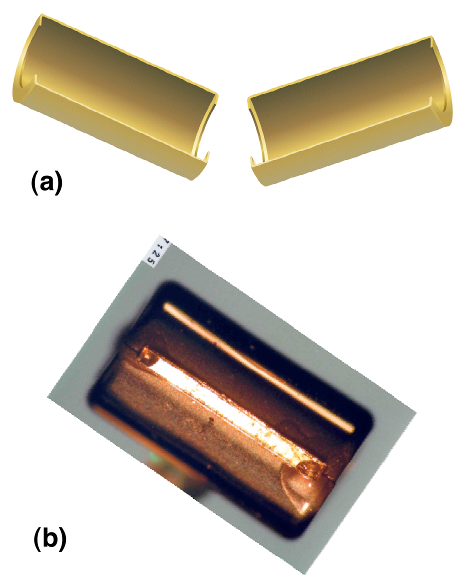

Figure 4(a): Schematic of hohlraum halves sputter coated on the inside with cocktail material. (b) Fully assembled hohlraum.

For comments about content of the ***Bimonthly Update,*** contact Bruce A. Hammel (925) 422-3299.
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